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Comments on NOνA Near Detector as presented 2/20/2007

Dear Hugh,

Thank you for the opportunity to comment on the issues of the NOνA near detector at this stage.

Few line summary: NOνA needs at least one near detector. I am not sure that one near detector will give them everything they need. They may need two near detectors and/or also need some specific measurements in a test-beam. I would encourage continued investigation.

NOνA presents as its first important goal detecting ν_e appearance and establishing a non-zero θ_{13}. To do this, NOνA needs to understand the background rate from mis-identified neutral currents, and the background rate from the ν_e content in the beam. I think it is sensible to design a near detector which will allow the far detector statistics to be the limiting capability of the experiment - for the planned exposure this implies a near detector matched to a value of 0.01 for $sin^2(2\theta_{13})$. Nature may be kinder and offer a larger $sin^2(2\theta_{13})$ but it seems wise to try to maximize the potential for return on the large investment given that the near detector is a small fraction ($< 5\%$) of the cost of the experiment.

Mark Messier's presentation was very informative and page numbers here refer to his talk. Page 6 is a nice summary of the numbers for ν_e appearance. An exposure of 750 $\times 10^{20}$ kton-p.o.t yields 32 background events in the current NOνA analysis, due equally to beam ν_e and neutral current background. A value of $sin^2(2\theta_{13}) = 0.01$ for this exposure would give about 20 oscillation events, slightly more than 3 sigma above the background, and so this is about the limit of the sensitivity to $sin^2(2\theta_{13})$.

There are systematic uncertainties on this background estimate; the estimates rely on simulation and Mark showed some of the challenges for this approach.

- The simulation requires as input the neutrino cross section around 2 GeV; this cross section is a sum of a few processes and neither the sum nor the individual components are known to better than 20% in this energy region. Some processes may be more liable to generate background than others so the mix matters in the simulation.

- The detector can of course be simulated with inputs from specific tests but the only convincing demonstration of the understanding of its response comes from its performance in practice.

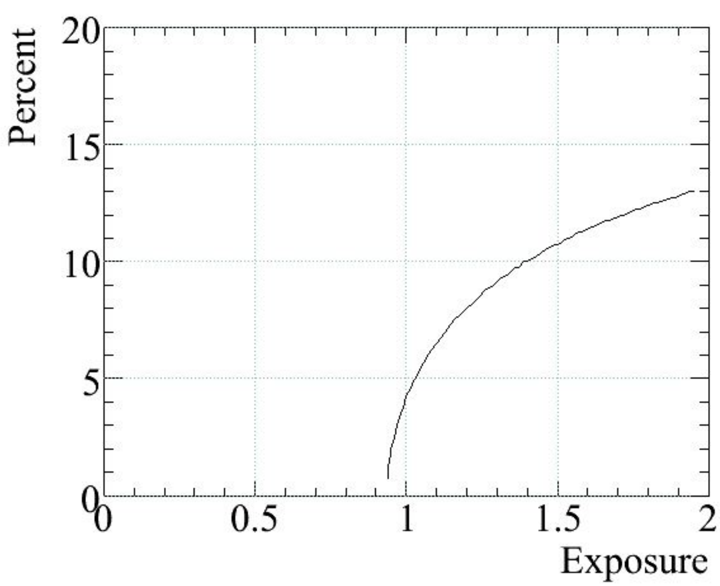
- Finally, there is the background from intrinsic ν_es in the beam, and their number has to be known.

Looking first at the neutral current background: An off-axis near detector sees a large flux of low energy ν_μ, a flux which the far detector does not see. Taking the numbers of accepted events at the far detector (page 6) and multiplying the ν_μ CC events by 10 for this effect, the background rate in the off-axis near detector will come equally from neutral current, charged current and intrinsic ν_e. Allowing perfect a priori knowledge of the ν_e, a question is whether the background rates from ν_μ and neutral current events can be separated to the required level. This may be possible but was not demonstrated in the presentation. One of the advantages of varying the angle of the near-detector was that the mix of charged current and neutral current events in the appropriate energy range changes with angle, allowing a possible cross check on this separation. Although this specific check is lost in the present proposal, NOνA may consider if the running on the surface as planned before installing in the tunnel could provide some useful input for this.

A near detector is important for aspects of the experiment beyond establishing the background to the ν_e appearance. A near detector is probably crucial for an improved measurement of ν_μ disappearance and the plots on page 17 show that the near-detector ν_μ spectrum in the passageway can be matched quite well to the far detector spectrum. The plots on page 18, it is noted, show that the position in the tunnel at which the ν_μ spectra are matched is not the position at which the ν_e near and far spectra are best matched. The optimum near detector position for the ν_e is further downstream, closer to the NuMI axis. This is a consequence of the near detector being so near the end of the decay-pipe that it sees a line source and the fact that many of the ν_es originate from μ decay which tends to occur towards the d/s end of the decay pipe. As we are all aware, a near detector further away (a kilometer or two) would not suffer this way.

Finally, a near detector can be used to monitor the beam; it can ensure that beam problems which the beam monitoring system may not catch, in particular problems with the target or horns, are identified rapidly; at worst it may allow data to be rescued for which beam problems were identified only after the data were taken. It may also be essential if for some reason the target material is changed.

I do not know the full program NOνA is planning in order to understand their experiment. I won't comment on the discussion of leaving open passage-way or not and who pays for it. I would like to help to ensure that the major investment in the experiment and the beam not be short-changed by skimping on the capabilities of the near-detector, or more generally by skimping on the program required to understand the data. Here is a plot Mark made for Steve Geer.



The horizontal axis is the exposure (in units of 750 $\times 10^{20}$ kton-p.o.t,) and the vertical axis is the assumed systematic error. The curve shows how the required exposure for a sensitivity to $sin^2(2\theta_{13}) = 0.01$ increases as the systematic uncertainty on the predicted background increases. The effort to achieve a systematic uncertainty below 10% and to monitor the beam seems well justified. If I would recommend one thing it is that discussions be continued on how these can be achieved.

Sincerely yours

Stephen Pordes